IJSPT

CASE REPORT

ECCENTRIC TRAINING FOR THE REHABILITATION OF A HIGH LEVEL WRESTLER WITH DISTAL BICEPS TENDINOSIS: A CASE REPORT

Dhinu J. Jayaseelan, PT, DPT[1]
Eric M. Magrum, PT, DPT, OCS, FAAOMPT[2]

ABSTRACT

Background and Purpose: Distal biceps brachii tendinosis is a relatively uncommon clinical diagnosis seen by physical therapists. As a result, there is little evidence guiding clinical decisions regarding best practice or effective treatment options to restore individuals to their previous level of function. The purpose of this case report is to describe the use of eccentric training as the primary intervention in the rehabilitation of a patient with distal biceps tendinosis.

Case Description: A 41-year-old male electrician and collegiate wrestling coach presented to a university outpatient physical therapy clinic with a two month duration of pain in the right antecubital space which occurred when the patient was performing close-grip body weight curl ups for the first time. Sharp pain was noted in the right arm during the lowering phase of the exercise. Following the examination, distal biceps tendinosis appeared to be the likely diagnosis. The patient was educated in eccentric exercise principles and was prescribed eccentric loading exercises for the distal biceps brachii tendon in two different positions of elbow flexion.

Outcomes: The patient was seen in physical therapy for three visits over the course of four weeks. Following eccentric training, the patient reported decreased pain, demonstrated increased right elbow flexion and forearm supination strength, was no longer tender to palpation of the distal biceps tendon and showed clinically significant improvement in QuickDASH scores.

Discussion: Given the lack of available research on the rehabilitation of distal biceps tendinosis, eccentric training showing benefits with other upper quarter tendinoses and the positive outcomes in this case, it may be appropriate for physical therapists to employ eccentric training for patients with distal biceps tendinosis.

Key Words: distal biceps, eccentric exercise, tendinosis

Level of Evidence: 5 (Single case report)

[1] Staff Physical Therapist, The George Washington University Hospital, Outpatient Rehabilitation Center, Washington, DC, USA

[2] Senior Physical Therapist, University of Virginia/HealthSouth Outpatient Sports Medicine, Charlottesville, VA, USA

No sources of grant support.

The George Washington University Medical Center was contacted regarding IRB approval. No specific submissions for approval are required for case studies with fewer than four (4) subjects.

CORRESPONDING AUTHOR

Dhinu Jayaseelan, PT, DPT
The George Washington University Hospital
Outpatient Rehabilitation Center
2131 K St. NW, Suite 620
Washington, DC 20037 (USA)
Phone: (202) 715-5369
Fax: (202) 715-5664
dhinu.jayaseelan@gwu-hospital.com

INTRODUCTION

Distal biceps brachii tendinosis is a relatively uncommon clinical diagnosis seen by physical therapists. As a result, there is little evidence guiding clinical decisions regarding best practice or effective treatment options to restore individuals to their previous level of function. Eccentric training is well documented as an effective method of rehabilitating both achilles and patellar tendinopathies[1-6] as well as more recently, tendinopathies of the upper quarter specifically the rotator cuff and wrist extensor mechanism.[7-14] Eccentric training of patients afflicted with these tendinopathies can result in positive changes in pain, function, and tendon characteristics.[15] Given these outcomes it seems reasonable to consider eccentric training as a potential intervention for the diagnosis of distal biceps tendinosis. The purpose of this case report is to describe the use of eccentric training as the primary intervention in the rehabilitation of distal biceps tendinosis.

Most authors have encouraged use of the term of tendonopathy versus tendinitis in describing overuse tendon injuries in athletes.[16] These recommendations in specific vocabulary are secondary to evolving evidence of histopathological classification defined by tendon degeneration without signs of inflammation. Understanding the differences in tendon pathology can allow clinicians to better treat these conditions.

Tendinosis is tendon degeneration resulting from a failed healing response without clinical or histological signs of inflammation.[17-19] Microscopic evaluation of tendinosis reveals collagen disorientation, disorganization and fiber separation by an increase of mucoid ground substance, increased prominence cells and vascular spaces with or without vascularization and focal necrosis or calcification.[17] It is not clear whether the initial event in the pathologic cascade occurs in the collagen matrix or the tenocyte.[20-22] Injury to the tendon may result in collagen fiber disruption that may either trigger mechanoreceptors or directly damage the tenocytes causing them to replicate and differentiate into fibrocytes, endothelial cells, and other mesenchymal-derived cells.[23] These cells then produce the hypercellularity, hypervascularity, collagen disorganization, and abnormal ground substance deposition seen in tendinosis lesions.[24] Another characteristic specific to tendinosis is neovascularization,[16] or the proliferation of capillaries and arterioles. This inappropriate tissue orientation leads to delayed healing which prolongs the duration an individual experiences symptoms, most frequently reported as pain, however the tendon may also be asymptomatic. Tissue biopsy or microscopy is typically required in order to define tendon dysfunction specifically as tendinosis. For the purposes of this case report, the phrase tendinosis represents a chronic tendinopathy, without confirming biopsy or microscopy having been performed.

Tendonitis is defined as an active inflammatory process within the substance of the tendon. The inflammatory process includes hemorrhage and organizing granulation tissue with fibroblastic proliferation.[16] The tendon is symptomatic with vascular disruption and an inflammatory reparative process. The duration of the inflammatory process can depend on a number of factors, but in most cases it lasts up to three weeks.

Paratenonitis is defined as inflammation of the paratenon or outer layer of the tendon; typically occurring where a tendon frictions over a bony protuberance. Typically paratenonitis presents with acute swelling and hyperemia progressing to inflammatory cells and fibrinous exudate within the tendon sheath with palpable crepitus.[16]

Incidence

To date the incidence of distal biceps tendinosis has not been well reported, with available literature discussing either partial or complete tendon ruptures. Specifically, the successful rehabilitation of an individual with distal biceps tendinosis has yet to be described in detail in current literature. Safran and Graham reported an incidence of distal biceps ruptures as 1.2 per 100,000 patients with the majority of injuries (86%) affecting the dominant arm.[25] Sutton and colleagues reported 90% of biceps brachii tendon ruptures occur at the proximal origin of the tissue while only 10% of biceps tendon ruptures are distal indicating a low frequency of distal bicep brachii injuries, with actual tendinosis being reported even less frequently.[26] Males in the 4th decade of life are more likely to undergo distal biceps tendon injuries, with injuries typically occurring between the ages of 30 and 60 years of age.[25,27] In addition to age, smokers have a 7.5 times increased risk of injury than non-smokers.[25]

Mechanism of Injury

The distal biceps tendon is most commonly injured when an eccentric force is applied to the flexed elbow, with patients typically complaining of a sudden, sharp, and painful tearing sensation in the antecubital region.[27-31] There are two main theories explaining possible predisposition of the distal aspect of the biceps to injury. The first deals with the vascular supply of the distal biceps. Proximally, the biceps brachii receives branches of the brachial artery, but the distal vascular supply comes from the smaller posterior interosseus artery. There is an approximate 2.14 cm zone of avascularity that can predispose the distal biceps tendon to injury.[32] The second theorized predisposition for distal tendon degeneration involves mechanical impingement of the biceps tendon at the proximal radioulnar joint. With the forearm in a fully pronated position, the distance between the lateral border of the ulna and the radial tuberosity is 48% less than the distance with the forearm fully supinated, thus decreasing the available space for the tendon. Also, with the forearm pronated, the biceps tendon occupied on average 85% of the radioulnar space at the level of the tuberosity.[32] While these theories have not been determined to be definite causes of biceps tendon pathology, they are the most widely reported in literature to date.

Anatomy

In order to effectively treat distal biceps dysfunction, clinicians must understand the anatomy. The biceps brachii consists of two heads: the short head which originates at the coracoid process and the long head which originates at the supragleniod tubercle before blending in with the superior aspect of the glenoid labrum and running along the intertubercular groove. Muscular actions include elbow flexion and forearm supination as well as assisting in glenohumeral flexion, glenohumeral abduction (if the humerus is externally rotated) and stabilizing and depressing the humeral head.

Ten of 17 subjects demonstrated two distinct parts of the distal biceps tendon insertion, each a continuation of the long and short heads of the biceps, with the remaining 7 subjects demonstrating interdigitation of the muscle.[33] The short head of the biceps typically inserts into the distal aspect of the radial tuberosity allowing it to be a more powerful elbow flexor, while the long head attaches more proximally on the radial tuberosity in a position to supinate the forearm. The bicipital aponeurosis (lacertus fibrosis) consists of three layers and completely encircles the ulnar forearm muscles, acting to stabilize the biceps tendons distally as well as the ulnar forearm musculature proximally.[33] Biceps brachii innervation comes from the musculocutaneous nerve, cervical roots C5 (primarily) and C6.

Case Description: Patient History and Systems Review

A 41-year-old male presented to physical therapy with severe localized pain in the right antecubital fossa which had been worsening in the previous two months. The onset of pain occurred when the patient was performing close-grip body weight curl ups for the first time, during which he experienced sharp pain during the lowering phase of the 10th repetition of the third set. In this case, close-grip curls ups were performed with hands approximately six inches apart and forearms supinated. Exacerbating activities included lifting heavy weights, wrestling motions involving extreme shoulder internal rotation and/or elbow flexion and he also noted some mild increased pain if he had to turn his palm up frequently at work into forearm supination. The patient was able to continue working full time as an electrician (which required frequent overhead activities) and coaching collegiate wrestling. No specific alleviating factors aside from rest were noted. No complaints of proximal pain were reported. No other significant past medical history or history of orthopedic injuries was reported. The patient was not taking any medications. No previous treatment had been reported aside from three days of complete rest with some benefit following the initial injury. The patient had no history of smoking and did not drink alcoholic beverages while in training. Previous diagnostic imaging included an x-ray which was normal. The patient was right hand dominant. The patient's activity level at time of evaluation included lifting weights and wrestling five times each week. Prior to the injury, the patient reported lifting weights and wrestling with about the same frequency since being a teenager, however intensity of both weight lifting and wrestling decreased following the injury secondary to pain. The patient had performed body weight pull ups and curl ups prior to the injury; however he did not perform close-grip curls ups prior to when the injury occurred.

The patient was scheduled to participate in a Veteran's level Greco-Roman wrestling tournament in Russia two months after the date of initial evaluation and wanted to alleviate symptoms as quickly as possible. The patient wanted to try physical therapy rather than undergo a platelet-rich plasma injection, an option presented to him by his orthopedic physician, because of his concern that injections might exacerbate his symptoms.

Clinical Impression #1:
After reviewing the medical intake form and obtaining a thorough history, distal biceps tendinosis was the initial clinical hypothesis. The patient reported a mechanism of injury consistent with biceps brachii pathology, noted localized pain at the distal aspect of the biceps brachii and had pain with elbow flexion and forearm supination, two actions of the biceps brachii. Based on the chronicity of the patient's symptoms, a tendinosis seemed more likely than a tendinitis. A partial tear and a tendinosis may present similarly, making differentiation with a clinical exam difficult. Diagnostic imaging, particularly ultrasound or magnetic resonance imaging (MRI) can be helpful to differentiate the two diagnoses.[34] Complete tendon rupture was not expected because the patient was able to continue with all activities, but performed them with pain. Cervical pathology seemed less likely because the patient did not report any symptoms with neck movement or positioning, and symptoms did not follow a particular cervical referral pattern.

By performing a thorough examination to confirm a tendinosis it would make eccentric training more appropriate, as a tendinitis typically heals from modified and limited activity rather than overloading inflamed tissues. Prior to examination the patient appeared appropriate for eccentric training given his reported symptoms consistent with a tendinosis, his high level of understanding of weight training principals and willingness to try conservative measures.

EXAMINATION

A thorough examination was performed of the patient in order to determine the specific tissues involved in causing the patient's symptoms:

Posture: In sitting, the patient presented with a forward head and protracted scapulae posture. In standing there was a noticeable improvement of posture as a visual and palpatory inspection revealed no significant findings or asymmetries in scapular boney landmarks (acromion and inferior angle position). Scapulohumeral rhythm during bilateral shoulder elevation was normal. Patient was 6'0" tall, 242 pounds with a mesomorphic musculoskeletal appearance.

Cardiopulmonary Screen: Blood pressure: 118/70 mmHg; resting heart rate: 58 bpm, 2+ (normal) pulse noted at both brachial and radial pulse sites; respiratory rate: 12 bpm; all within normal limits

Cervical Screen: Negative for reproduction of symptoms or discomfort

Range of Motion (ROM): Upper extremity active ROM was within functional limits and pain free throughout. Active and passive ROM at the elbow was pain free.

Sensation: Intact to light touch throughout bilateral neck/upper extremities in all dermatomal distributions.

Palpation: Localized tenderness was noted at the right distal biceps tendon insertion at the radial tuberosity and running proximally for 2 cm over the biceps tendon in the antecubital fossa. Palpation of the medial and lateral epicondyles, the common wrist flexor and extensor tendons, brachioradialis, brachialis, supinator, median, ulnar and radial nerves did not reproduce pain. No retraction or defect consistent with a complete rupture was noted. No warmth or swelling was present when compared bilaterally. The biceps muscle belly and proximal biceps tendon were not tender to palpation.

Myotomes: Grossly 5/5 bilaterally in the neck/upper extremities except the right elbow flexors which were 4/5 and demonstrated pain upon resistance testing.

Manual muscle testing (MMT): Right elbow flexion with forearm supinated (to bias biceps brachii): 4/5 with reproduction of pain at the distal biceps tendon; elbow flexion with the forearm in neutral ('hammer curl' position to bias brachioradialis): 4/5 with reproduction of pain at the distal biceps tendon; elbow flexion with the forearm pronated (to bias brachialis): 5/5 with report of slight pain at the distal biceps; supination: 4/5 and pain free

'Special' Tests: Yergason's, Speed's, Hook, and Bicep Squeeze tests all yielded negative results. The procedures, indications and available statistical information of these tests can be seen in Appendix 1.[35-37]

Reflexes: Biceps, brachioradialis and triceps were normal (2+) and symmetrical bilaterally

Neural Tension: Upper limb tension test (ULTT) median nerve bias was negative bilaterally

Diagnostic Ultrasound: Hypoechoic signal was noted throughout the length of the distal tendon and location of pain. Substantial enlargement of the right distal biceps tendon was not noted when compared to the left.

Pain Score (verbal analog scale: 0-10, 0 being no pain, 10 being worst pain ever experienced): Current: 5/10; Least since onset: 5/10; With activity: 10/10; Worst since onset: 10/10.

QuickDASH (Three sections each scored 0-100, 0 is no disability): Main module: 27.3; work module: 0; sports/performing arts module: 87.5

Clinical Impression #2

Given the fact that the patient's symptoms were brought on by particular motions involving the biceps brachii coupled with the patient's report of a traumatic onset, non-mechanical sources of pain causing symptoms were ruled less likely. The patient's cardiovascular screen was normal and no complaints of ischemic type pain were reported, indicating vascular compromise of the area was also unlikely. A cervical screen was negative as was a neural screen (ULTT, reflexes and light touch sensation) ruling out a radicular or nerve entrapment source of symptoms. Given the anatomy and function of the biceps brachii, injury to the distal aspect is generally accompanied by pain and/or weakness with resisted elbow flexion and/or supination both of which were noted with this patient. Proximal biceps brachii involvement was ruled out by the absence of symptoms, and negative Speed's and Yergason's tests. Given the point tenderness along the distal biceps tendon, mechanism of injury, and ruling out of proximal bicep involvement it appeared that the right distal biceps brachii tendon was the tissue involved.

With a tendinitis, physical markers of inflammation such as edema, redness or warmth may be expected. These signs were not present with this patient. Also, this patient had been experiencing symptoms for two months prior to coming to therapy, long after a tendinitis would be expected to last. Additionally, the patient was able to continue all daily and vocational activities using the right biceps brachii (duties required of an electrician, carrying his children, etc) without being limited by pain, and participate in wrestling and weight lifting with pain. If a tendinitis was the pathology, symptoms would likely limit all activities stressing the involved tissues, not necessarily just activities with heavy weights or large resistance. Diagnostic ultrasound imaging can also be an effective method of determining the appropriate pathology. A tendinosis typically appears as hypoechoic swelling of the tendon on diagnostic ultrasound, as compared to hypoechoic tendon fiber disruption seen frequently with a tendon tear.[38] Partial tears are usually characterized by enlargement and abnormal contour of the tendon, with peritendinous fluid (edema, bursitis, hemorrhage) occasionally seen.[39] Although substantial enlargement was not noted at the right distal biceps tendon, hypoechoic swelling consistent with tendinosis was visualized.

Plain radiographs sometimes show hypertrophic bone formation at the radial tuberosity with partial tears[27] however, radiographs of the elbow of this patient did not show significant abnormalities. With a complete rupture, the proximal position of the biceps muscle belly is often visually readily apparent.[31] This was not the case with this patient, making a complete rupture less likely. Based on the results of the examination, the initial hypothesis of distal biceps tendinosis was made more likely.

Informal re-evaluation was performed at each follow up visit. Formal reassessment of tests and measures performed during the initial evaluation was performed four weeks after initial evaluation (one month prior to the competition). Objective measures comparing initial evaluation and the patient's status at discharge can be seen in Table 1. Outcome measures were pain, strength, tenderness to palpation and QuickDASH scores. The QuickDASH is an abbreviated version of

Table 1. *Outcome measurements at initial evaluation and discharge.*

		Initial Evaluation	4 Week Follow Up
Pain	At rest	5/10	0/10
	At worst	10/10	0/10
QuickDASH	Main module	27.3%	0%
	Work module	0%	0%
	Sports module	87.5%	0%
Strength	Elbow flexion (3 positions):		
	1) forearm in neutral	4/5, pain	5/5, pain free
	2) forearm pronated	5/5, pain	5/5, pain free
	3) forearm supinated	4/5, pain	5/5, pain free
	Forearm supination	4/5, pain	5/5, pain free
Tenderness	Distal biceps tendon	(+) on right	(-) on right

the validated Disabilities of the Arm, Shoulder and Hand (DASH) outcome measure, investigating a patient's reported level of disability in upper extremity function. With this outcome measure, lower scores are indicative of less disability while higher scores indicate greater reported disability. The minimum clinically important difference (MCID) has been determined to be 8 points.[40]

INTERVENTION

Eccentric contractions occur as the muscle is lengthening under an external load. During eccentric training, the involved limb is used to control the lowering phase (muscle lengthening), while the uninvolved limb performs the concentric phase in order to return the weight to the starting position. The patient is told to perform this exercise even if they experience pain (as muscle contractions of damaged tendons can be painful), however the patient is told to stop exercising if the pain becomes disabling. Weight is increased when the patient can perform the eccentric loading without experiencing any minor pain or discomfort.[1]

Visit 1 (initial evaluation): Given the likely clinical diagnosis of distal biceps tendinosis, the patient was educated and trained with eccentric loading for elbow flexion with the forearm supinated (Figure 1) and with the forearm in neutral (Figure 2). The patient was instructed to use a weight that was uncomfortable or slightly painful, but not disabling (this weight was determined to be 30#, as the patient felt 25# was too easy, however 35# was too painful and the patient was unable to maintain proper form). The patient demonstrated appropriate performance using a cable column in the physical therapy gym. Training was to be performed every day, at 3 sets of 7 repetitions, increasing weight in increments of 5 pounds if 7 repetitions were reported as easy or pain-free. There is some inconsistency in exercise prescription for eccentric loading.[11] The patient was prescribed fewer repetitions than Alfredson's achilles protocol[1] (3 sets of 15 repetitions, 2 times each day) because the patient was performing the activity in two different positions (increasing total number of eccentric loading repetitions). Also it was the author's hypothesis that fewer repetitions would be needed to overload the distal biceps tendon than the Achilles or patellar tendons which are involved in repetitive weight-bearing activities such as gait (where resistance under normal loads is greater than in the upper extremity). Significant time was spent with patient education regarding the eccentric training process and its physiology. In addition, patient education was provided regarding proper posture (specifically trying to maintain spinal neutral and avoiding protracted scapular positioning) and the idea of proximal stability in order to facilitate proper mobility distally.[41,42] The patient was scheduled for a follow up in two weeks, and was instructed to contact the physical therapist should any questions arise or if symptoms were to worsen.

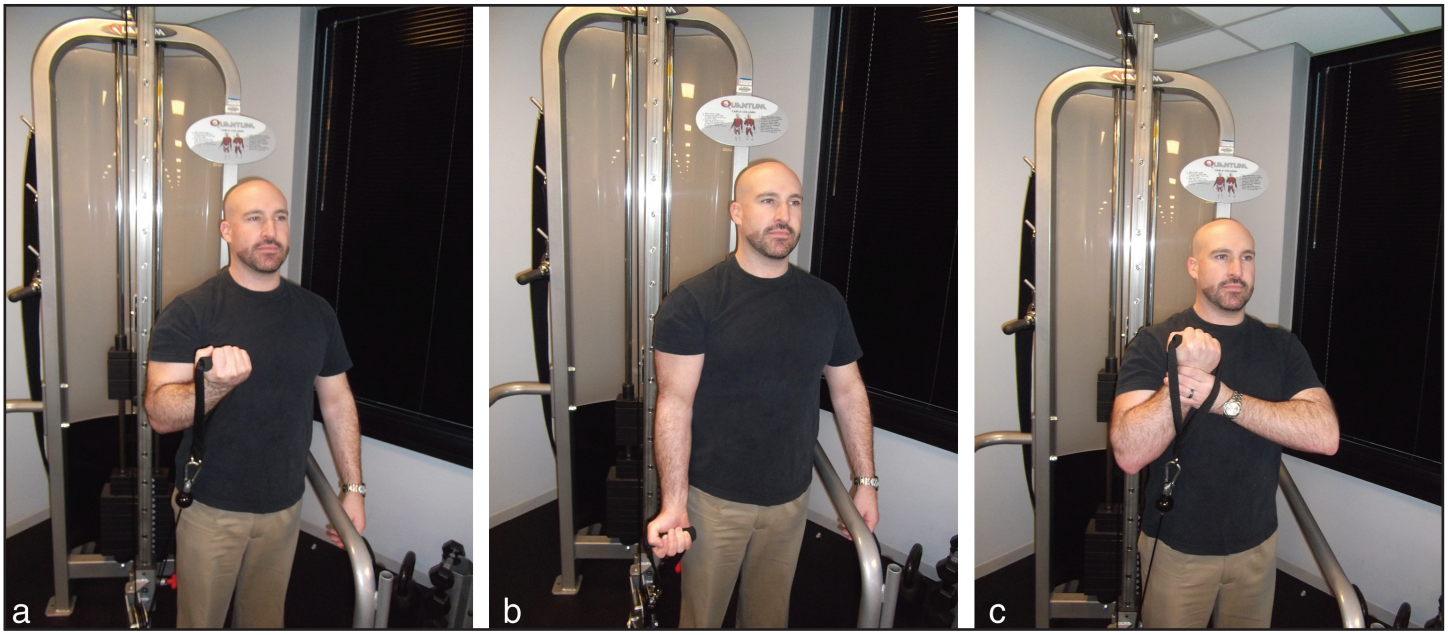

Figure 1. *Eccentric elbow flexion with the forearm supinated, a) starting position of the lowering phase, and the patient slowly lowers the weight with the involved extremity, b) ending position of the lowering phase, c) the contralateral arm is used to return the weight to the starting position.*

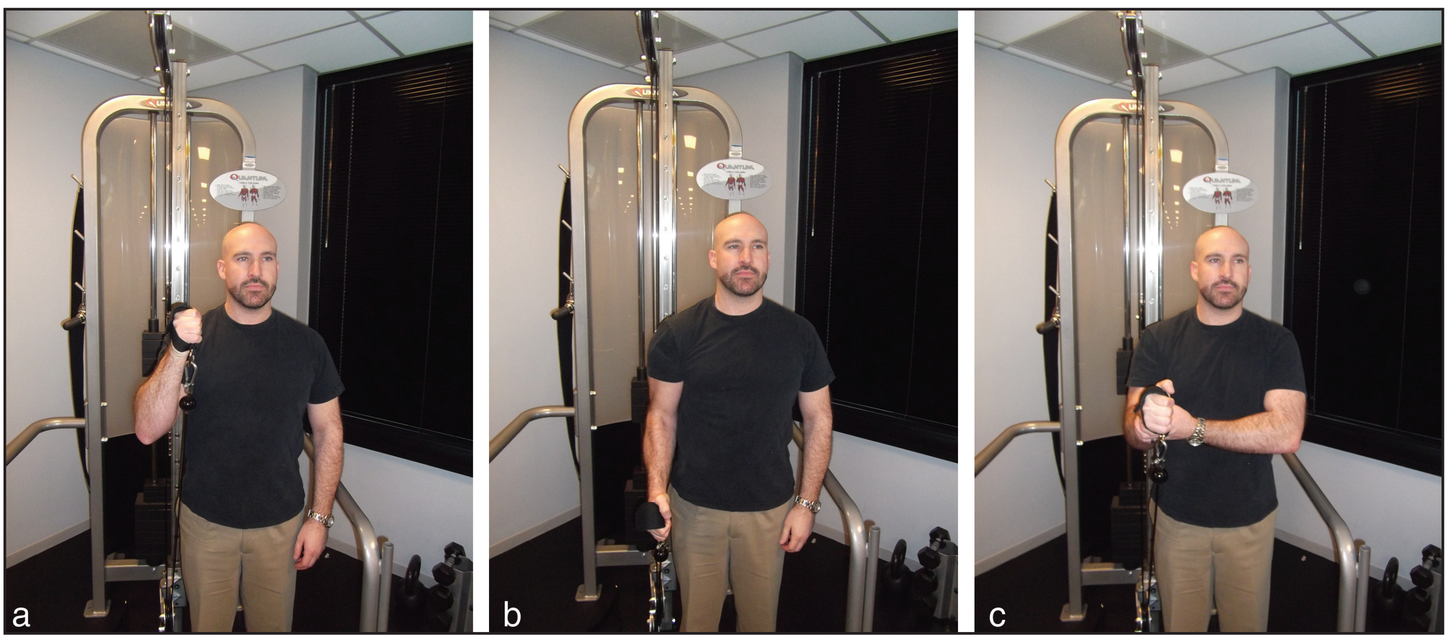

Figure 2. *Eccentric elbow flexion with the forearm in neutral, a) starting position of the lowering phase, and the patient slowly lowers the weight with the involved extremity, b) ending position of the lowering phase, c) the contralateral arm is used to return the weight to the starting position.*

Visit 2 (2 weeks after initial evaluation): The patient reported compliance with eccentric training over the previous two weeks. Subjectively, the patient reported pain was decreasing at rest and with exacerbating activities but remained (1/10 at rest, 5/10 at worst). Objectively, no significant improvements were noted with muscle strength testing; however less pain was reported with all motions. Tenderness remained at the distal biceps tendon, but again was reported with decreased intensity. After proper form without compensation was demonstrated to the physical therapist with increased weight (40#) in both positions, the

Figure 3. *Normal grip push-ups on a BOSU® ball (Hedstrom Fitness, Ashland, OH) with lower extremities on a theraball – starting position.*

Figure 4. *Close grip push-ups on a BOSU® ball (Hedstrom Fitness, Ashland, OH) with lower extremities on a theraball – starting position.*

patient was instructed to continue with eccentric training increasing weight as needed to continue to overload the involved tissues and remain in an uncomfortable/painful range. Sitting posture improved, as the patient was able to sit with decreased forward head/rounded shoulder positioning without cues. The patient also reported noticing himself sitting and standing in a neutral scapular position more frequently at home and at work. Resisted wrist flexion and extension was introduced to increase neuromuscular control at the elbow (5#, 3 sets of 10 repetitions each exercise, 5 times each week). The patient was also given a gentle self-stretch for the elbow flexors, which involved passively extending the wrist of the involved arm with the contralateral hand all while the involved elbow remained in extension. This stretch was to be held for 30 seconds each repetition, performing 2-3 repetitions, 2-3 times a day. Performance of the new activities was correct without compensation or increased pain. The patient was scheduled for another follow up visit in two weeks.

Visit 3 (4 weeks after initial evaluation): The patient reported continued compliance with the HEP. The patient reported no pain with previously exacerbating factors and demonstrated no pain with resistive testing of elbow flexion (three positions) or with palpation. Eccentric exercises were performed with correct technique with increased weight (55#) using a cable column. With continued improvement in symptoms, new activities were incorporated to force co-contraction of the upper quarter and trunk, which commonly occurs during wrestling. When training the upper quarter for wrestling, activities should emphasize both single and double-extremity movements focusing on stability and proprioception.[43] Activities were normal (Figure 3) and close grip (Figure 4) pushups on a BOSU® ball (Hedstrom Fitness, Ashland, OH) with feet on a theraball, a challenging exercise forcing co-contraction during a dynamic activity on an unstable surface. Also added was a serratus anterior exercise with the cable column. While kneeling on a BOSU® ball and starting with resistance in the upper extremity, the patient slowly allows the weight to return towards the cable column making sure to control scapular protraction (Figure 5). The patient performed the new exercises with proper form and no pain. The patient was educated to incorporate the new exercises into his current exercise program, performing 3 sets of 10 repetitions for each exercise, 5 times a week.

OUTCOME

The patient was seen in physical therapy for three visits including the initial evaluation over the course of four weeks. At the third visit, the patient was pain free with all work, sport and recreational activities and had been for the previous week. The Quick-DASH was reassessed at the third visit with scores of 0% in the main, work, and sports modules, indicating no reported upper extremity dysfunction. The patient was happy with the progress made as he was able to return to pre-injury status and had decided

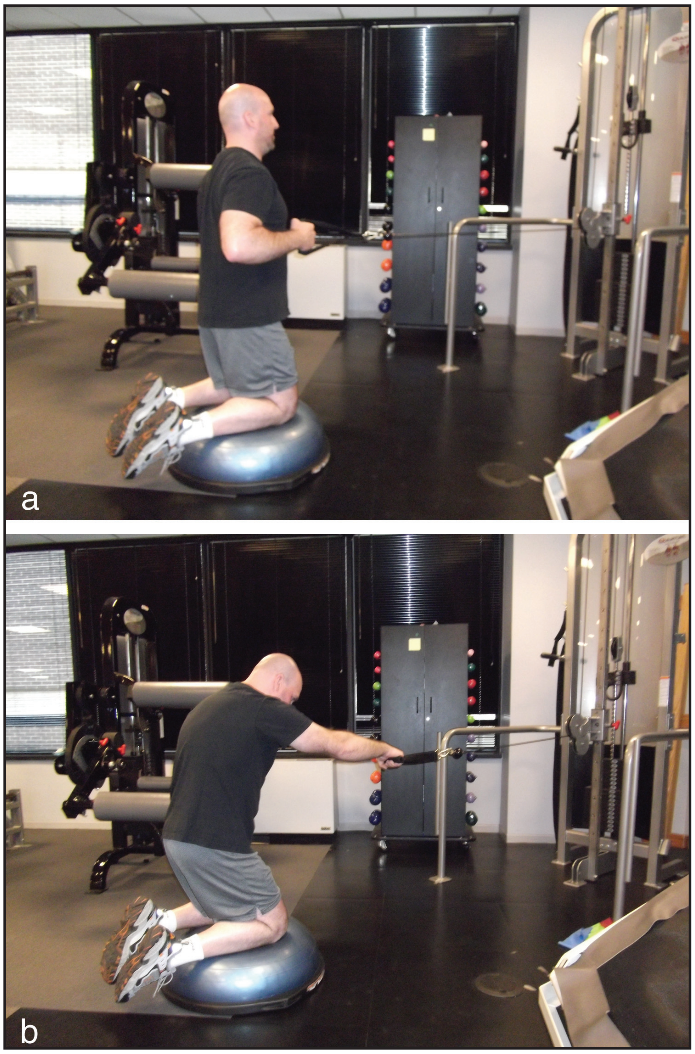

Figure 5. *Controlled serratus anterior exercise on an unstable surface, a) starting position; the active arm slowly controls the scapula coming into protraction, b) ending position.*

not to undergo a platelet-rich plasma injection. The patient was discharged as a result of accomplishing all goals, being independent with his HEP and being pain free. The patient had the physical therapist's contact information should questions arise regarding his care or should his symptoms change. An e-mail received two weeks following the third visit (6 weeks after initial evaluation) revealed that the patient remained pain free despite an increase in training intensity. In a follow up e-mail six months after initial evaluation checking for long term improvement, the patient mentioned that he was able to participate in the wrestling tournament without pain, finishing third in his weight class. The patient also mentioned that he was not experiencing any pain in his arm, and was not limited functionally with any recreational or vocational activities.

DISCUSSION AND CONCLUSIONS

To date there has been little literature describing distal biceps tendinosis or its rehabilitation. By definition, a tendinosis is an abnormal collection of disorganized collagen fibers, which can delay proper healing following injury.[44] Mechanical loading of tissues is believed to accelerates tenocyte metabolism and may speed repair.[45] Eccentric training has been shown to be beneficial for the treatment of tendinosis by normalizing tendon structure.[46]

Numerous studies have demonstrated positive outcomes with eccentric training for upper quarter tendinopathies, particularly the rotator cuff and wrist extensor mechanism.[7-14] Because eccentric training has not been shown to have detrimental effects and in light of the positive outcomes of other upper quarter tendinoses, it may be appropriate for physical therapists to attempt eccentric training for patients with distal biceps tendinosis as similar tissue healing principles apply.

There are a number of limitations associated with this case report. In this particular case, the patient was instructed to perform 3 sets of 7 repetitions of eccentric elbow flexion with the forearm in neutral and in supination each day, less than Alfredson's established protocol of 3 sets of 15 repetitions two times each day for Achilles tendinosis.[1] This recommendation has not been validated for the distal biceps tendon in previous research, but was still effective. This may be because the patient's high level of function at onset of therapy and his performance of additional eccentric loading of the biceps tendon against resistance while wrestling. It was the physical therapist's hypothesis that the achilles tendon is active with gait, a repetitive activity performed throughout the day with full body weight, and may require more repetitions of eccentric contractions to overload. Because the biceps brachii is typically used less frequently to produce less force, the physical therapist felt fewer repetitions would be needed to overload the tendon, addressing abnormal collagen cross-links and facilitating proper healing and pain free function. Also, many of the studies previously performed on the effect of an eccentric training protocol on tendinopathies implemented a 12 week program duration, longer than this particular patient performed eccentric training, making a direct correlation between this case and supportive research difficult. Despite the longer duration of training with previous studies, there have been positive outcomes shown within four weeks of eccentric training for tendinosis.[47] Logistically, this patient was a wrestling coach at a university who had free access to weights to perform eccentric activities, which may have aided his recovery. Some patients may not have access to gyms, so household items (i.e. a weighted bag or backpack) may need to be utilized to overload tissues in accordance to eccentric loading principles. This is also the first article describing a rehabilitation program of a distal biceps tendinosis using eccentric training. Additional research is needed to determine the clinical utility of eccentric training in this patient population.

It should also be made clear that although this patient presented with an isolated distal biceps tendinosis, a complete evaluation of every patient should be performed. Every attempt should be made to assess and correct impairments in posture, strength, ROM and neuromuscular control that may increase the physical demand on the biceps during daily, vocational, or recreational activities. It is the authors' hope that this case report will increase awareness of distal biceps tendinosis and facilitate continued investigation into the most effective conservative treatment interventions in order to effectively and efficiently maximize a patient's pain free level of function.

REFERENCES

1. Alfredson H, Pietila T, Jonsson P, et al. Heavy-load eccentric calf muscle training for the treatment of chronic achilles tendinosis. *Am J Sports Med.* 1998;26:360-6.
2. Magnussen RA, Dunn WR, Thomson AB. Nonoperative treatment of midportion achilles tendinopathy: A systematic review. *Clin J Sport Med.* 2009;19:54-64.
3. Rompe JD, Furia J, Maffulli N. Eccentric loading versus eccentric loading plus shock-wave treatment for midportion achilles tendinopathy: A randomized controlled trial. *Am J Sports Med*. 2009;37:463-470.
4. Rompe JD, Nafe B, Furia JP, et al. Eccentric loading, shock-wave treatment, or a wait-and-see policy for tendinopathy of the main body of tendo Achillis: A randomized controlled trial. *Am J Sports Med*. 2007;35:374-383.
5. Carcia CR, Martin RL, Houck J, et al. Achilles pain, stiffness, and muscle power deficits: Achilles tendinitis. *J Orthop Sports Phys Ther*. 2010;40(9): A1-26.
6. Visnes H, Bahr R. The evolution of eccentric training as treatment for patellar tendinopathy (jumper's knee): A critical review of exercise programmes. *Br J Sports Med*. 2007;41(4):217-23.
7. Bernhardsson S, Klintberg IH, Wendt GK. Evaluation of an exercise concept focusing on eccentric strength training of the rotator cuff for patients with subacromial impingement syndrome. *Clin Rehabil*. 2011;25(1):69-78.
8. Rees JD, Wilson AM, Wolman RL. Current concepts in the management of tendon disorders. *Rheumatology (Oxford)*. 2006;45(5):508-21.
9. Jonsson P, Wahlström P, Ohberg L, et al. Eccentric training in chronic painful impingement syndrome of the shoulder: Results of a pilot study. *Knee Surg Sports Traumatol Arthrosc*. 2006;14(1):76-81.
10. Croisier JL, Foidart-Dessalle M, Tinant F, et al. An isokinetic eccentric programme for the management of chronic lateral epicondylar tendinopathy. *Br J Sports Med*. 2007;41(4):269-75.
11. Malliaras P, Maffulli N, Garau G. Eccentric training programmes in the management of lateral elbow tendinopathy. *Disabil Rehabil*. 2008;30(20-22):1590-6.
12. Svernlov B, Adolfsson L. Non-operative treatment regime including eccentric training for lateral humeral epicondylalgia. *Scand J Med Sci Sports*. 2001;11(6):328-34.
13. Soderberg J, Grooten WJ, Ang BO. Effects of eccentric training on hand strength in subjects with lateral epicondylagia: A randomized-controlled trial. *Scand J Med Sci* Sports. 2011; Epub ahead of print.
14. Tyler TF, Thomas GC, Nicholas SJ, et al. Addition of isolated wrist extensor eccentric exercise to standard treatment for chronic lateral epicondylosis: A prospective randomized trial. *J Shoulder Elbow Surg*. 2010;19(6):917-22.
15. Woodley BL, Newsham-West RJ, Baxter GD. Chronic tendinopathy: Effectiveness of eccentric exercise. *Br J Sports Med*. 2007;41(4):188-98.
16. Maffulli N, Wong J, Alkekinders LC. Types and epidemiology of tendinopathy. *Clin Sports Med*. 2003 22:675-692.
17. Dutton M. *Orthopaedic Examination, Evaluation and Intervention*. 2nd Edition. New York, NY: McGraw-Hill Companies; 2008.
18. Khan KM, Cook JL, Bonar F, et al. Histopathology of common overuse tendon conditions: Update and implications for clinical management. *Sports Med.* 1999;27:393–408.

19. Alfredson H. In situ microdialysis in tendon tissue: High levels of glutamate, but not prostaglandin E2 in chronic achilles tendon pain. *Knee Surg Sports Traumatol Arthrosc.* 1999;7:378–81.
20. Kaeding C, Best TM. Tendinosis: Pathophysiology and nonoperative treatment. *Sports Health: A Multidisciplinary Approach.* 2009;1:284-292.
21. Almekinders LC. Tendinitis and other chronic tendinopathies. *J Am Acad Orthop Surg.* 1998;6: 157-164.
22. Jozsa L, Kannus P. Overuse injuries of tendons. In: *Human Tendons: Anatomy, Physiology, and Pathology.* Champaign, IL: Human Kinetics; 1997:164-253.
23. Cook JL, Feller JA, Bonar SF, et al. Abnormal tenocyte morphology is more prevalent than collagen disruption in asymptomatic athletes' patellar tendons. *J Orthop Res.* 2004;22:334-338.
24. Rolf CG, Fu BS, Pau A, et al. Increased cell proliferation and associated expression of PDGFRbeta causing hypercellularity in patellar tendinosis. *Rheumatology.* 2001;40:256-261.
25. Safran MR, Graham SM. Distal biceps tendon ruptures: Incidence, demographics, and the effect of smoking. *Clin Orthop Relat Res*. 2002;(404):275-83.
26. Sutton KM, Dodds SD, Ahmad CS, et al. Surgical treatment of distal biceps rupture. *J Am Acad Orthop Surg.* 2010;18:139-148.
27. Ramsey ML. Distal biceps tendon injuries: Diagnosis and management. *J Am Acad Orthop Surg*. 1999;7(3):199-207.
28. Quach T, Jazayeri R, Sherman OH, et al. Distal biceps tendon injuries--current treatment options. *Bull NYU Hosp Jt Dis*. 2010;68(2):103-11.
29. Bain GI, Johnson LJ, Turner PC. Treatment of partial distal biceps tendon tears. *Sports Med Athrosc*. 2008;16(3):154-61.
30. Miyamoto RG, Elser F, Millett PJ. Distal biceps tendon injuries. *J Bone Joint Surg Am*. 2010;92(11):2128-38.
31. Vanhees M, van Riet R.P. Reconstruction after distal biceps tendon rupture. *Journal of Orthopaedics, Trauma and Rehabilitation.* 2011;doi:10.1016/j. jotr.2011.07.00
32. Seiler JG 3rd, Parker LM, Chamberland PD, et al. The distal biceps tendon. Two potential mechanisms involved in its rupture: arterial supply and mechanical impingement. *J Shoulder Elbow Surg*. 1995;4(3):149-56.
33. Eames MH, Bain GI, Fogg QA, et al. Distal biceps tendon anatomy: a cadaveric study. *J Bone Joint Surg Am*. 2007;89(5):1044-9.
34. Rummeny EJ, Reimer P, Heindel W. *MR Imaging of the Body*. 1st Edition. Stuttgart, Germany: Thieme; 2009.
35. Kibler WB, Sciascia AD, Hester P, et al. Clinical utility of traditional and new tests in the diagnosis of biceps tendon injuries and superior labrum anterior and posterior lesions in the shoulder. *Am J Sports Med*. 2009;37(9)1840-47.
36. O'Driscoll SW, Goncalves LB, Dietz P. The hook test for distal biceps tendon avulsion. *Am J Sports Med*. 2007;35:1865-9.
37. Ruland RT, Dunbar RP, Bowen JD. The biceps squeeze test for diagnosis of distal biceps tendon ruptures. *Clin Orthop Relat Res*. 2005;437:128-31.
38. Jacobson J. *Fundamentals of Musculoskeletal Ultrasound*. 1st Edition. Philadelphia, PA: Saunders Elsevier; 2007.
39. Chew ML, Giuffre BM. Disorders of the distal biceps brachii tendon. *Radiographics*. 2005;25(5):1227-37.
40. The DASH Outcomes Measure: Disabilities of the Arm, Shoulder and Hand. *Frequently Asked Questions*. Available at http://www.dash.iwh.on.ca/faq.
41. Kibler WB, McMullen J, Uhl T. Shoulder rehabilitation strategies, guidelines, and practice. *Orthop Clin North Am*. 2001;32(3):527-38.
42. Sciascia A, Cromwell R. Kinetic chain rehabilitation: a theoretical framework. *Rehabil Res Pract.* 2012;2012:853037.
43. Grindstaff TL, Potach DH. Prevention of common wrestling injuries. *Strength and Conditioning Journal*. 2006;28(4):20-28
44. Khan K, Cook J. The painful nonruptured tendon: clinical aspects. *Clin Sports Med*. 2003;22(4):711-25.
45. Kannus P, Jozsa L, Natri A, et al. Effects of training, immobilization and remobilization on tendons. *Scand J Med Sci Sports*. 1997;7:67-71.
46. Ohberg L, Lorentzon R, Alfredson H. Eccentric training in patients with chronic Achilles tendinosis: normalised tendon structure and decreased thickness at follow up. *Br J Sports Med*. 2004;38(1):8-11.
47. Mayer F, Hirschmüller A, Müller S, et al. Effects of short-term treatment strategies over 4 weeks in achilles tendinopathy. *Br J Sports Med*. 2007;41(7):e6.

Appendix 1. *Biceps brachii special tests.*

Test	Procedure	Interpretation	Sensitivity	Specificity	Likelihood Ratio (LR)
Yergason's[35]	With the patient's elbow flexed to 90°, stabilized against the thorax, and forearm pronated, the examiner manually resisted supination while the patient also externally rotated the arm against resistance.	A positive result was pain over the bicipital groove and/or subluxation of the long head of the biceps brachii, indicating proximal biceps tendonitis or instability	0.41	0.79	+LR: 1.94 –LR: 0.74
Speed's[35]	With the patient's arm elevated to 90° of forward flexion, the elbow extended, and the forearm supinated. The examiner applied resistance distal to the elbow in the direction of arm extension	A positive test is indicated by localized pain over the bicipital groove, indicating proximal biceps tendon dysfunction; may also be indicative of a SLAP lesion	0.54	0.81	+LR: 2.77 –LR: 0.58
Hook[36]	While the patient actively supinates with the elbow flexed 90 degrees, an intact hook test permits the examiner to hook his or her index finger under the intact biceps tendon from the lateral side	A positive result is where there is no cord-like structure under which the examiner may hook a finger, indicating distal biceps tendon avulsion	1.00	1.00	+LR: ∞ –LR: ∞ (based on one study)
Squeeze[37]	Similar to the Thompson test for an Achilles tendon rupture, the biceps muscle belly is squeezed in order to elicit a contraction	If no forearm supination is elicited with squeezing the muscle belly a complete rupture may be indicated.	0.96	Not Reported	Not Reported